

GROUND-WATER PROSPECTS
ALONG THE NATCHEZ TRACE PARKWAY
TENNESSEE



U.S. GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

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Geological Survey

GROUND-WATER PROSPECTS ALONG THE NATCHEZ TRACE PARKWAY, TENNESSEE


by
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Water Resources Division

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INTRODUCTION

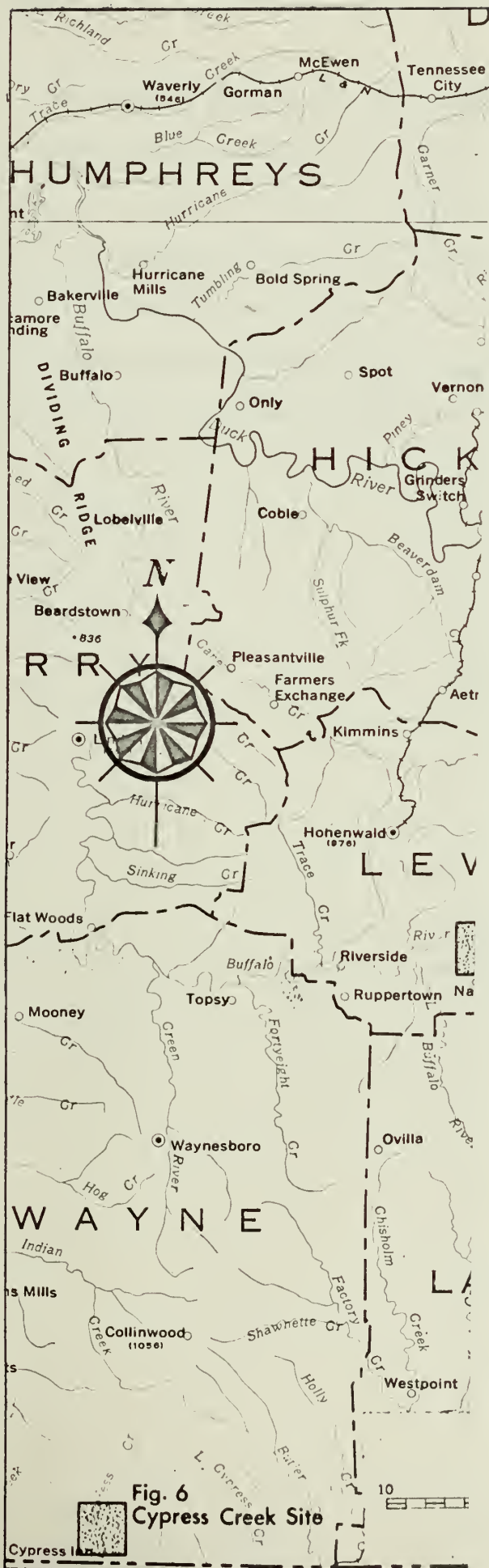
On February 27, 1968, the Geological Survey was requested by National Park Service to make a preliminary study of prospects for ground-water supplies at five sites along the Natchez Trace Parkway. These sites are Leipers Fork Subdistrict Headquarters, Nashville Terminus, Gordon House Historic Area, Cypress Creek Picnic Area, and Metal Ford Historic Site (fig. 1). Water supplies will be needed at these sites for comfort

Figure 1.--(caption on next page) belongs near here.

stations, residences, or other miscellaneous purposes. This report summarizes the geology, describes the ground-water prospects, and makes recommendations for the location of test wells.

It was impossible to treat each site in the same manner. The conditions at some sites seem to be equivalent to nearby areas which have been studied in detail. A somewhat more quantitative interpretation was made for these sites than at those sites which seem to represent special or unusual ground-water conditions.

The conclusions and recommendations for each site are summarized in the final section called "proposals."



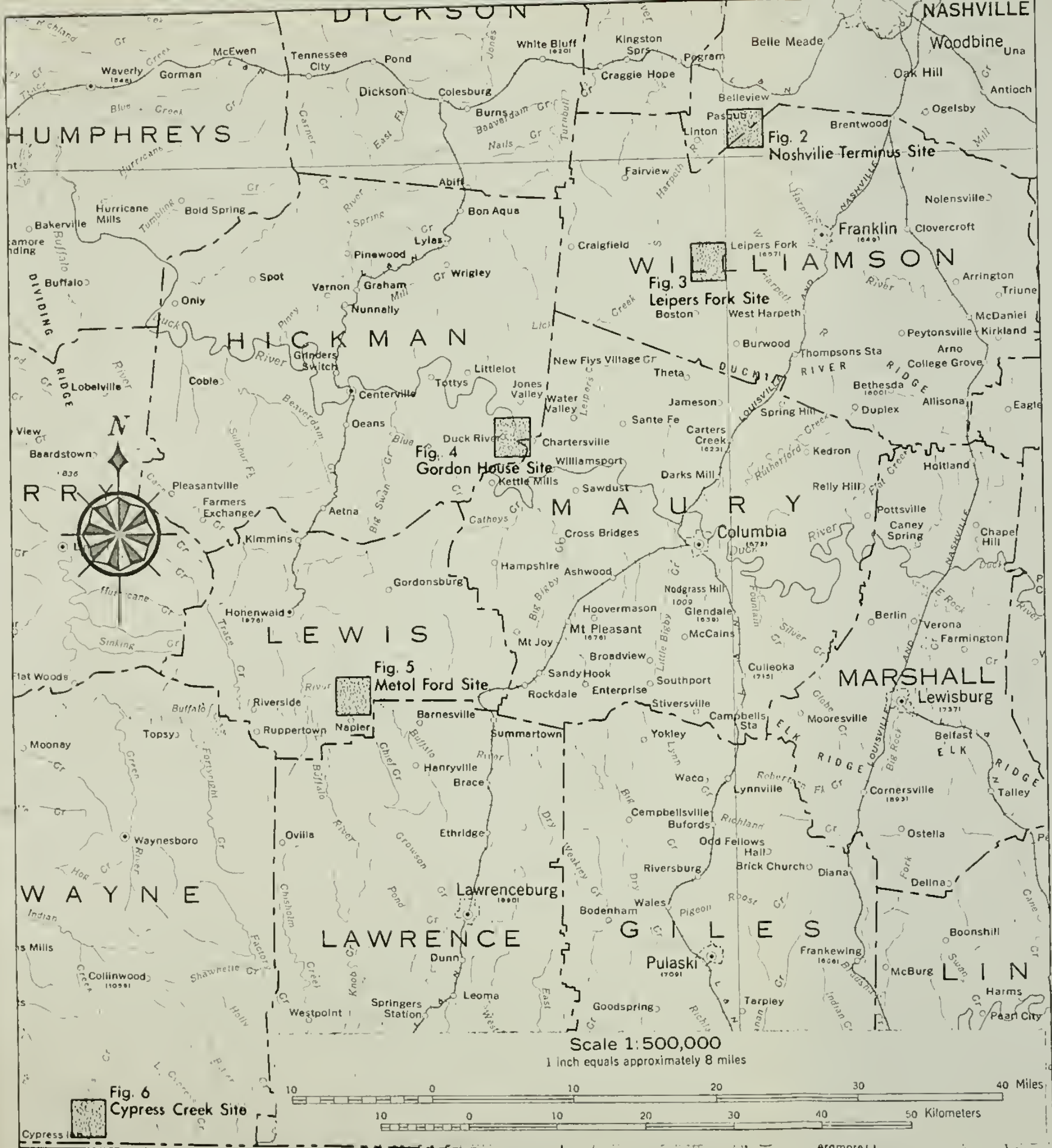


Fig. 1.--Index to the location of figures 2, 3, 4, 5, and 6, which include the Nashville Terminus, Leipers Fork, Gordon House, Metal Ford, and Cypress Creek sites.

The geology and some of the ground-water aspects are nearly identical at Leipers Fork, Nashville, and Gordon House. In order to eliminate repetition, all of the similar conditions pertaining to these sites are described in one section of the report. Some conditions at these sites differ and these are described in the sections called "special conditions." The geology and ground-water conditions at Cypress Creek and Metal Ford are described in the sections of the report concerning these sites.

LEIPERS FORK, NASHVILLE TERMINUS, AND GORDON HOUSE

Geology*

In the Nashville Terminus and Leipers Fork areas (figs. 2 and 3)

Figures 2 and 3.--(captions on next page) belong near here.

the Fort Payne Formation of Mississippian age with the Chattanooga Shale of Mississippian and Devonian age at its base caps the hills. In both areas these formations crop out above an altitude of 760 feet. The Fort Payne consists of very siliceous limestone, dolomite, and siltstone. In most places the Fort Payne has weathered to a very cherty residuum which makes up part of the overburden above bedrock. The black Chattanooga Shale is about 20 feet thick. The Richmond Group of Ordovician age that underlies the Chattanooga Shale at Nashville where it is about 30 feet thick is missing at Leipers Fork. The Richmond Group consists of coarse-grained to fine-grained and shaley limestone. The valley floor at both Nashville and Leipers Fork is underlain by the Leipers and Catheys Formations of Ordovician age. These formations are fine-grained, thin-bedded limestones, about 180 feet thick at Nashville but only about 90 feet thick at Leipers Fork.

*The geologic nomenclature used in this report conforms to that of the Tennessee Department of Conservation, Division of Geology, and is not necessarily the same as that of the U.S. Geological Survey.

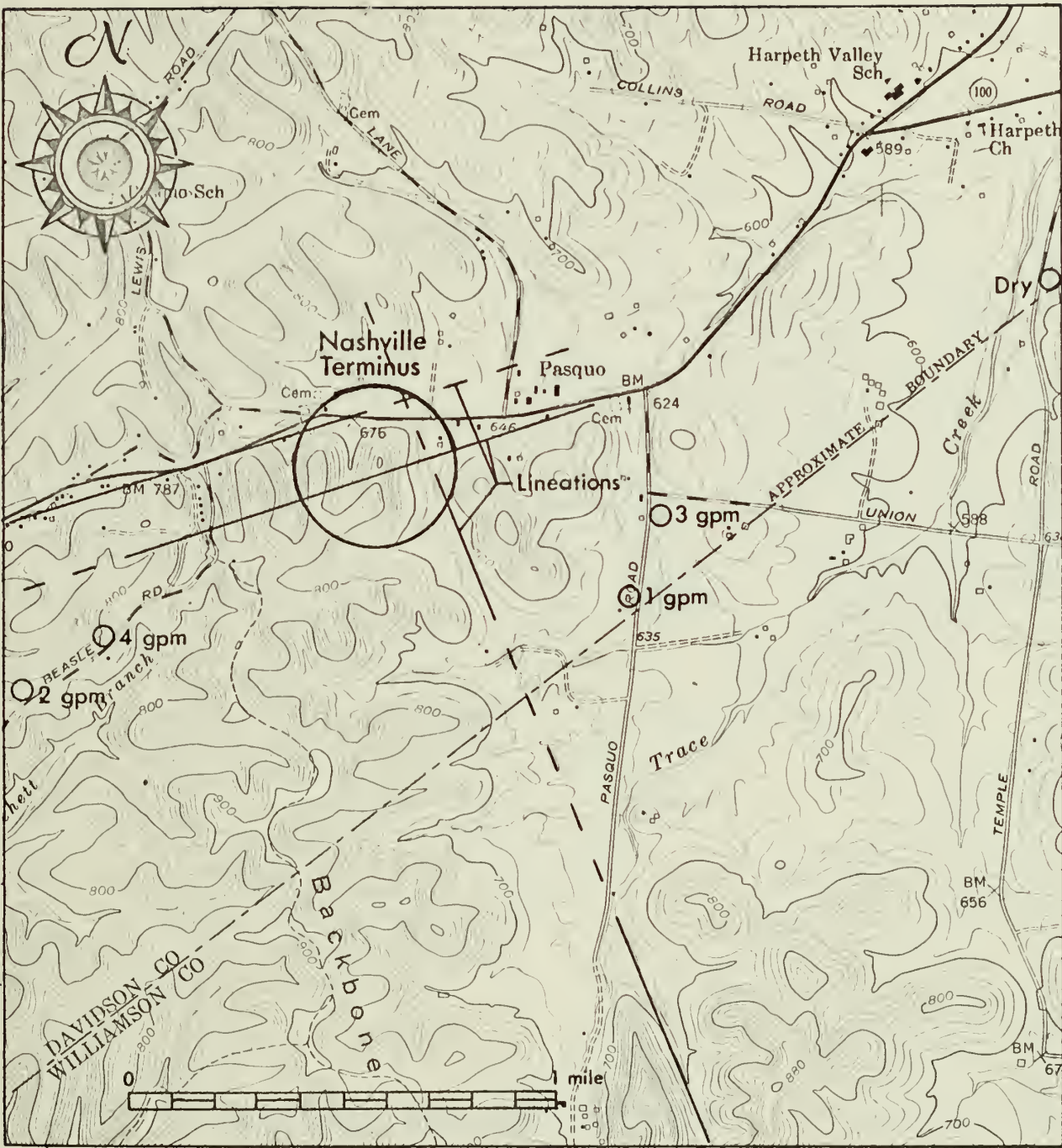


Fig. 2.--Location of Nashville Terminus showing lineations and the yield of nearby wells.

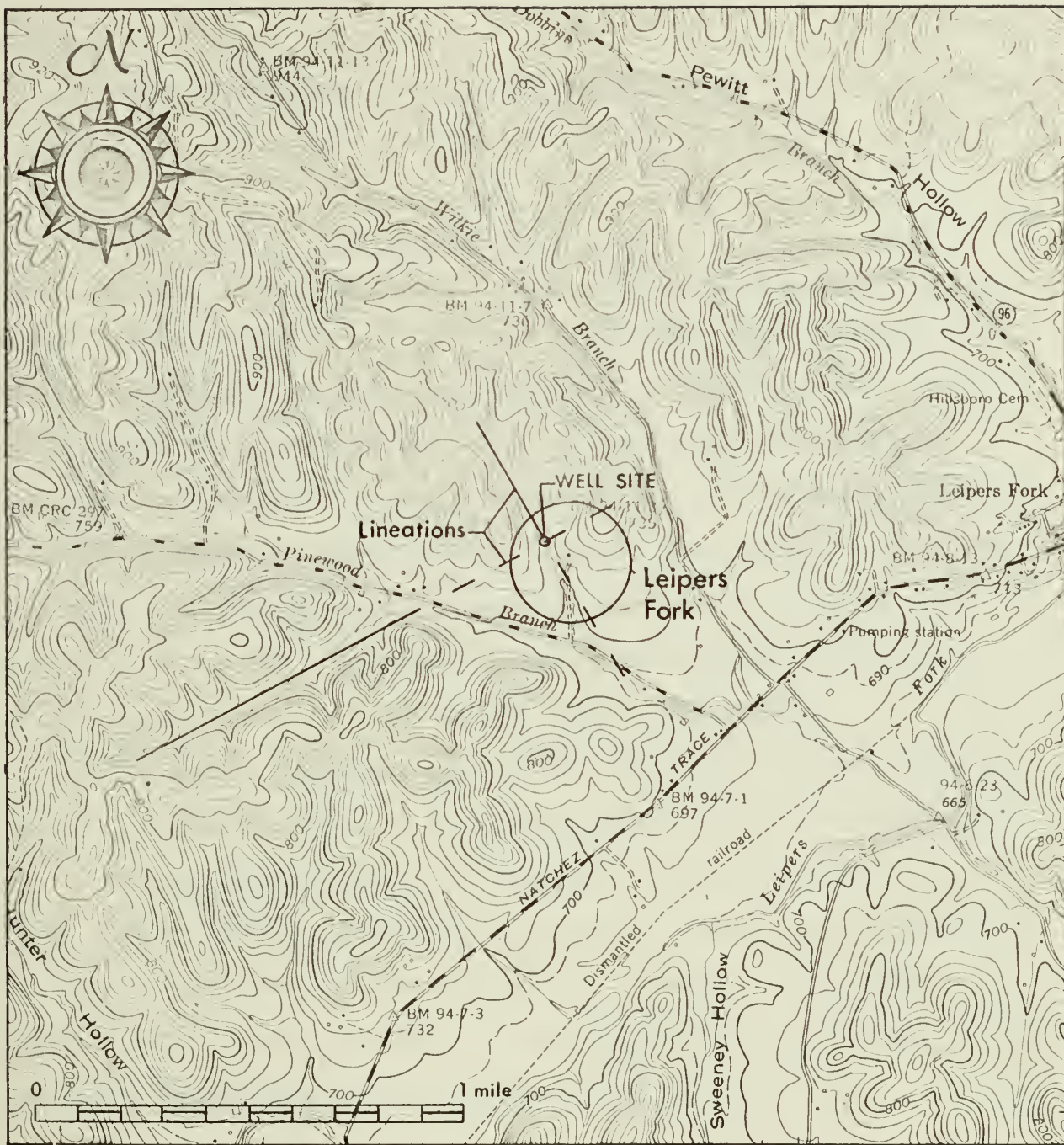


Fig. 3.--Location of Leipers Fork Subdistrict Headquarters showing lineations and a proposed well site.

The Bigby-Cannon Limestone of Ordovician age is the youngest formation exposed in the Gordon House area (fig. 4) and caps the hilltop. In the

Figure 4.--(caption on next page) belongs near here.

Nashville Terminus and Leipers Fork areas, the Bigby-Cannon underlies the Leipers and Catheys Formations and occurs only in the subsurface. At Gordon House, the Bigby-Cannon consists of a medium- to coarse-grained calcarenite and crops out above an altitude of 560 feet. The Hermitage Formation of Ordovician age underlies the Bigby-Cannon at all three sites; it crops out only in the valley floor at Gordon House. The Hermitage generally consists of a laminated, shaley limestone which is very fine to medium grained. It is about 70 feet thick at Gordon House.

The sybsurface formations at all three sites consist of an alternating sequence of coarse-grained and fine-grained limestones of Ordovician age.

All of the outcropping formations and the subsurface formations to a depth of 300 feet below land surface are water bearing--they yield water to wells in some parts of central Tennessee. Between a depth of 300 feet and the top of the Knox Dolomite, at a depth of more than 1,000 feet, only a very few, small water bearing zones have been reported.

Question?
Answer?

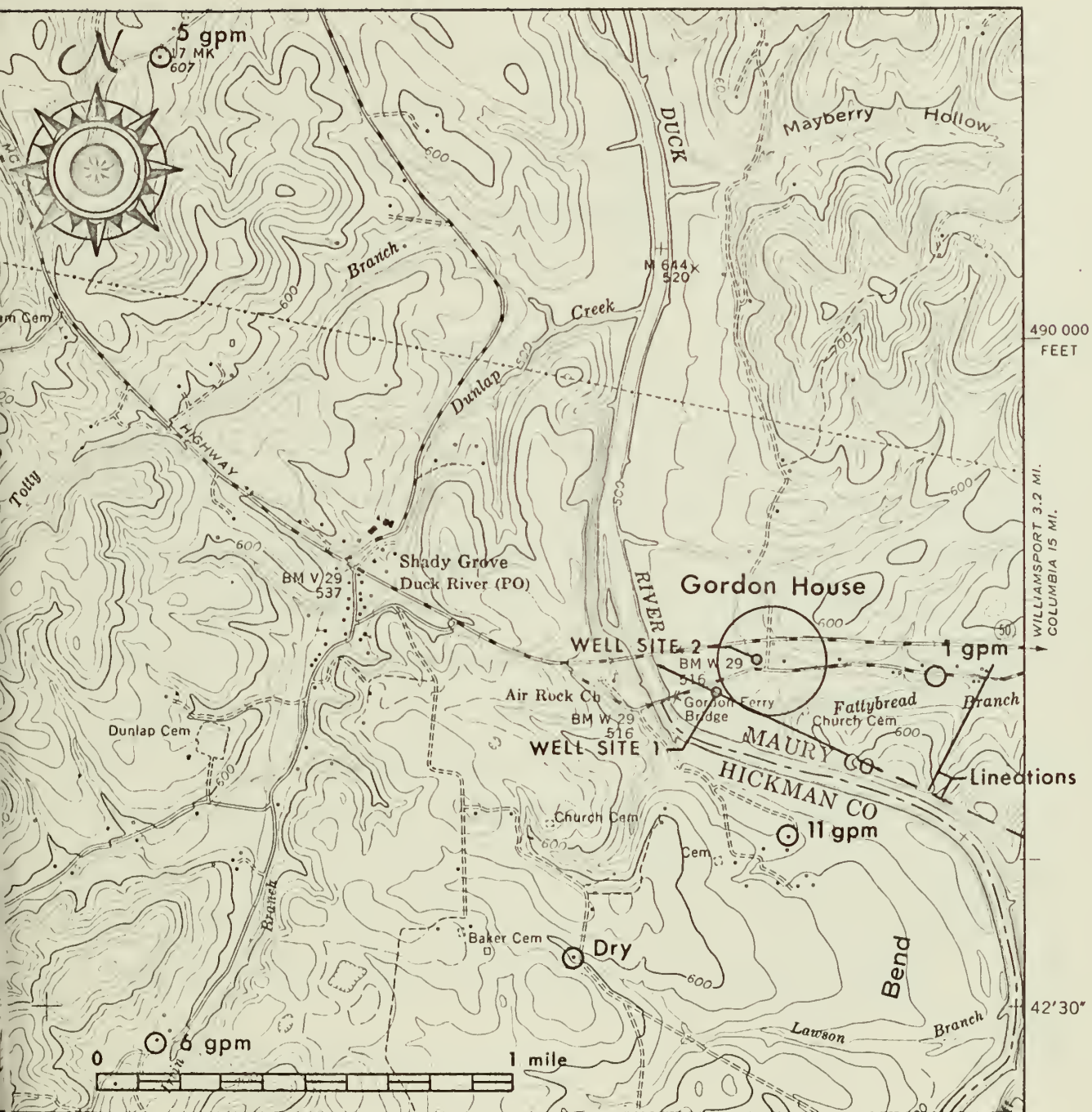


Fig. 4.--Location of Gordon House Historic Area showing lineations, two alternate proposed well sites, and the yield of nearby wells.

The Knox Dolomite of Cambro-Ordovician age is the deepest water-bearing formation and consists of fine- to coarse-grained beds of dolomite and limestone. The top of the Knox is about 1200 feet below land surface at Nashville Terminus, 1050 feet at Gordon House, and 1150 feet at Leipers Fork; the Knox is about 5000 feet thick.

Ground Water

The overburden in the Leipers Fork, Nashville, and Gordon House areas is thin and is not likely to yield an adequate amount of water.

There are two possible zones for ground water in the bedrock formations at Leipers Fork, Nashville, and Gordon House. One zone is in the shallow aquifers extending downward from land surface to a depth of 300 feet; the other zone is in the Knox Dolomite. The availability of ground water in the shallow aquifers decreases with depth. An analysis of 600 well records in central Tennessee showed that in 50 percent of the wells, water was found before reaching a depth of 55 feet. In 80 percent of the wells, water was found before reaching a depth of 120 feet, and only 2 percent of the wells had to go deeper than 300 feet. A depth of 300 feet, therefore, is a practical limit to water availability in the shallow aquifers.

There is a correlation between topographic position and well yields from the shallow aquifers. Test holes on shallow slopes near the base of hills, as at Leipers Fork and Gordon House have a 33 percent chance of either being dry or yielding less than 4 gpm (gallons per minute), a 23 percent chance of yielding 5-9 gpm, a 22 percent chance of yielding 10-19 gpm, a 12 percent chance of yielding 20-49 gpm, and a 10 percent chance of yielding 50 gpm or more.

The yields of all known wells near Nashville Terminus are low (fig. 2) and the odds above probably should not be applied to this area.

Water from the shallow aquifers almost always has a hardness in excess of 200 mg/l (milligrams per liter), and the average hardness is about 300 mg/l. The water from a few wells contains more than 250 mg/l of sulfate and 0.3 mg/l of iron, and thus exceeds the U.S. Public Health Service recommended limits for these constituents. The optimum value for fluoride varies with air temperature and is 0.9 mg/l at Nashville Terminus and 0.8 mg/l at Leipers Fork and Gordon House. The water from a few wells in the shallow aquifers contains more than twice the optimum amount of fluoride; by Public Health standards for drinking water, this constitutes grounds for rejection of the water supply. In addition, a few wells yield water containing detectable amounts of hydrogen sulfide gas. Most wells, however, yield water that is suitable for domestic use without treatment.

The upper 150 feet of the Knox Dolomite is a reliable source of water, providing some water to virtually all wells drilled into it. Well yields range from 1 to 50 gpm, but most wells yield less than 10 gpm. The top of the Knox is at an altitude of about 450 feet below sea level at Leipers Fork and about 500 feet below sea level at Nashville Terminus and Gordon House.

The quality of water from the upper 150 feet of the Knox Dolomite is fair to poor. Dissolved solids are usually less than 1000 mg/l. Iron was more than 0.3 mg/l in 25 percent of the samples. Chloride exceeded 250 mg/l in about one third of the wells but rarely exceeded 500 mg/l. Sulfate exceeded 250 mg/l in about 40 percent of the samples. Fluoride exceeded 1 mg/l in most wells and exceeded 4 mg/l in about 30 percent of the wells sampled. Standards set by the Public Health Service state that dissolved solid should not exceed 500 mg/l and chloride should not exceed 250 mg/l where more suitable water can be obtained.

Only a few small water-bearing zones have been reported between 150 and 500 feet below the top of the Knox Dolomite. Several wells in central Tennessee have been reported to have "large yields" from a depth between 500 and 600 feet below the top of the Knox. The water is reported to be "fresh." Nothing else is known about these deep water-bearing zones.

Special Conditions at Leipers Fork

Joints in the Leipers Fork area are vertical and strike about $N60^{\circ}E$ and $N30^{\circ}W$. Two joints in the area show up as good lineations on aerial photographs (fig. 3). The trend of underground solution cavities in the shallow aquifers is partially controlled by joints. Although there is no assurance that the lineations mark the position of underground cavities, a well location along a lineation has just as good, and perhaps a better chance of intercepting a solution cavity than a well located elsewhere in the area. Accordingly, a well location was selected at the intersection of the two lineations.

There is no information available on the yield of nearby wells or the quality of water from the shallow aquifers or the Knox Dolomite within 2 miles of the site. Most Knox wells elsewhere in Williamson County yield 2 to 6 gpm.

Special Conditions at Nashville Terminus

The joints in the Nashville Terminus area are vertical and strike about N20°W and N70°E. The traces of three joints in the area are seen as good lineations on aerial photographs. It is suggested that a test well be along one of the three lineations or at the intersection of two lineations.

Test holes drilled into the shallow aquifers in the surrounding area are dry or yield less than 5 gpm. This fact reduces the probability of obtaining a large well yield from the shallow aquifers in the Terminus area. It is possible that well yields larger than 5 gpm could be obtained anywhere in the Terminus area, but it is not very likely. Drilling at a site along a lineation increases the chance of obtaining a larger well yield but this chance cannot be evaluated.

Nearby wells in the upper part of the Knox Dolomite yield from 1 to 20 gpm. The most likely range in yield for a well at Nashville Terminus is 4 to 10 gpm.

Special Conditions at Gordon House

In the Gordon House area the joints are vertical and strike about N30°E and N60°W. The traces of two joints in the area are seen as fair lineations on aerial photographs. It is suggested that the first test hole be along one of the lineations.

Test holes in the shallow aquifers in the surrounding area are dry or yield from 1 to 11 gpm. The most likely yield from the shallow aquifers in the Gordon House area is 4 to 6 gpm.

Wells throughout Maury County and Hickman County that penetrated the upper part of the Knox Dolomite have reported yields from 1 to 15 gpm. The most likely yield from the Knox in the Gordon House area is 5 to 10 gpm.

METAL FORD HISTORIC SITE

Geology

The Metal Ford area (fig. 5) is underlain by the Fort Payne Formation,

Figure 5.--(caption on next page) belongs near here.

a siliceous limestone containing lenses and layers of limy chert up to 1-foot thick. The Fort Payne Formation is 280 feet thick, is overlain by porous chert of the Warsaw Limestone, and is underlain by the black Chattanooga Shale. The base of the Fort Payne is about 120 feet below land surface at the proposed well sites. The Fort Payne Formation contains numerous joints, which are well exposed in Buffalo River and in the bluffs immediately south of the parking area. The joints are vertical and strike about N10°W and N80°E. The linear nature of Buffalo River north of the proposed well sites indicates that the river is joint controlled--it follows the joint. An extension of this lineation passes up an unnamed hollow south of the proposed well sites.

A seismic survey was made on April 18, 1968 at the well location shown on figure 5. Although the survey was not specifically designed to determine depth to bedrock, results of the survey indicated that bedrock probably is about 10 feet below land surface. The overburden, which consists of silt and clay at the surface, also probably contains numerous chert fragments near the top of the bedrock.

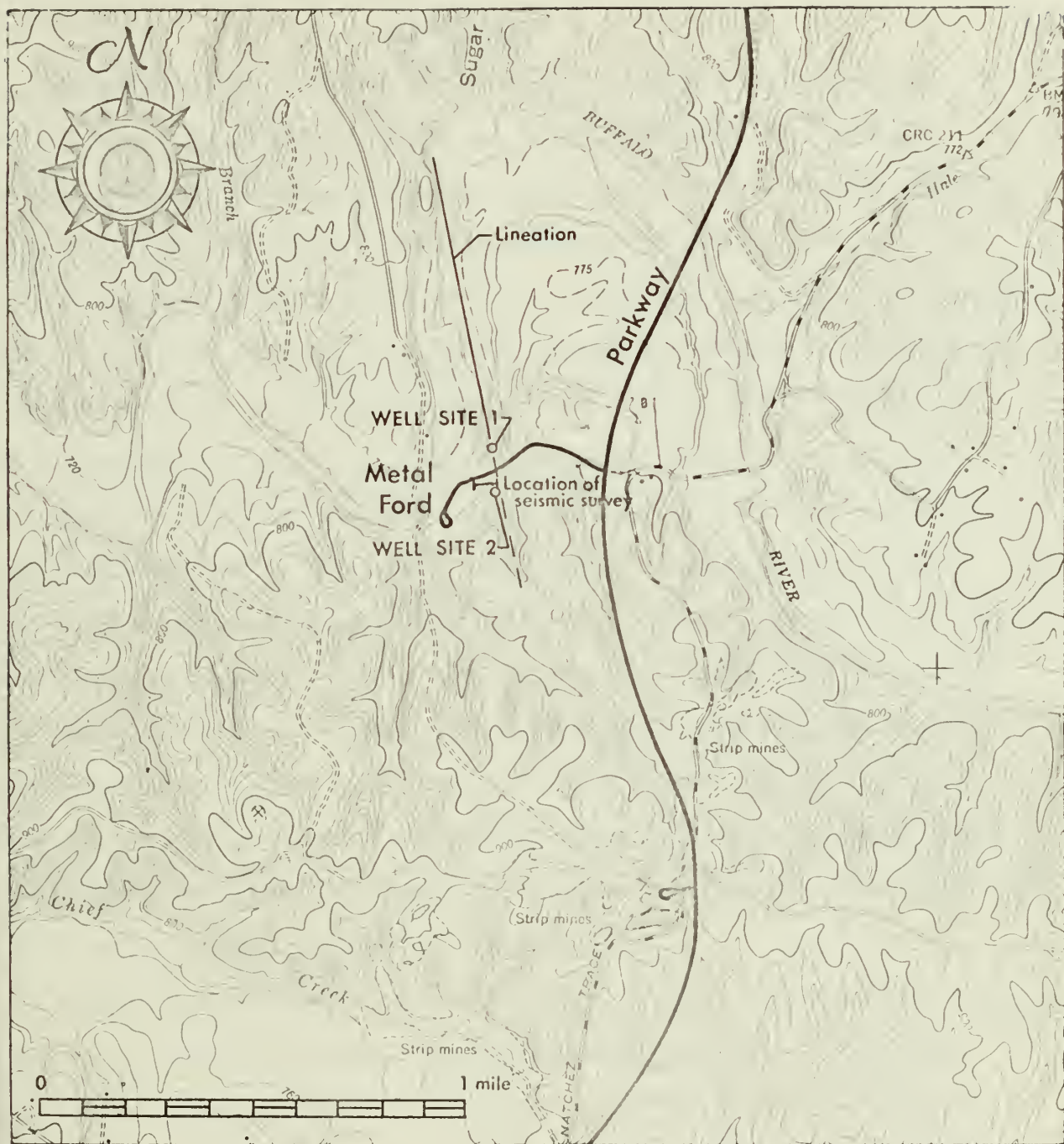


Fig. 5.--Location of Metal Ford Historic Site showing a lineation, two alternate proposed well sites, and the seismic survey made April 18, 1968.

Ground Water

The overburden is thin and is not likely to yield an adequate amount of water. Nearly all ground water will be found in fractures and solution openings in the Fort Payne Formation. There is very little likelihood that additional water can be found below the Chattanooga Shale.

The seismic survey indicated that the shock waves traveled at an average velocity of 17,000 fps (feet per second) through the bedrock at the west end of the survey line, but at an average velocity of only 11,000 fps through the bedrock at the east end. This indicates that either the rock at the east end has a different composition than that at the west end or that the rock at the east end is fractured. A difference in composition probably would have no effect on ground-water availability, but if these results were caused by fractures, the chances of obtaining a successful well may be very good indeed. Additional evidence for a correlation of the seismic results with ground water availability is provided by the fact that the lineation connecting Buffalo River with the unnamed hollow mentioned previously passes through the east end of the seismic-survey line. Accordingly, well sites 1 and 2 (fig. 5) were selected along this lineation.

The following estimates of well yield are based on experience with other wells having similar geological and topographical settings. They do not consider the possible effects of the lineation mentioned above because its effects cannot be evaluated. A test well probably would have an 8 percent chance of being a dry hole, an 80 percent chance of yielding 5 gpm or more and a 60 percent chance of yielding 10 gpm or more.

Water from bedrock of the Fort Payne Formation usually ranges from hard (120 to 180 mg/l) to very hard (more than 180 mg/l). A very few wells yield water that has a detectable hydrogen sulfide odor or has an iron content of more than 0.3 mg/l. Otherwise the water is suitable for domestic use without treatment.

CYPRESS CREEK PICNIC AREA

Geology

The Cypress Creek area (fig. 6) is immediately underlain by rounded

Figure 6.--(caption on next page) belongs near here.

gravel mixed with sand and clay. The gravels range up to 4 inches in diameter. At depth the gravel probably is smaller and more angular. Layers of solid chert up to 2 feet thick occur within the overburden, probably in the lower half. Beneath the overburden is bedrock of the Fort Payne Formation, a siliceous limestone or dolomite containing lenses and layers of limy chert 1 to 2 feet thick. The Fort Payne is underlain by the black Chattanooga Shale. The depth to the Chattanooga cannot be predicted accurately. However, the contact is almost certainly less than 200 feet below land surface and probably is less than 150 feet below land surface.

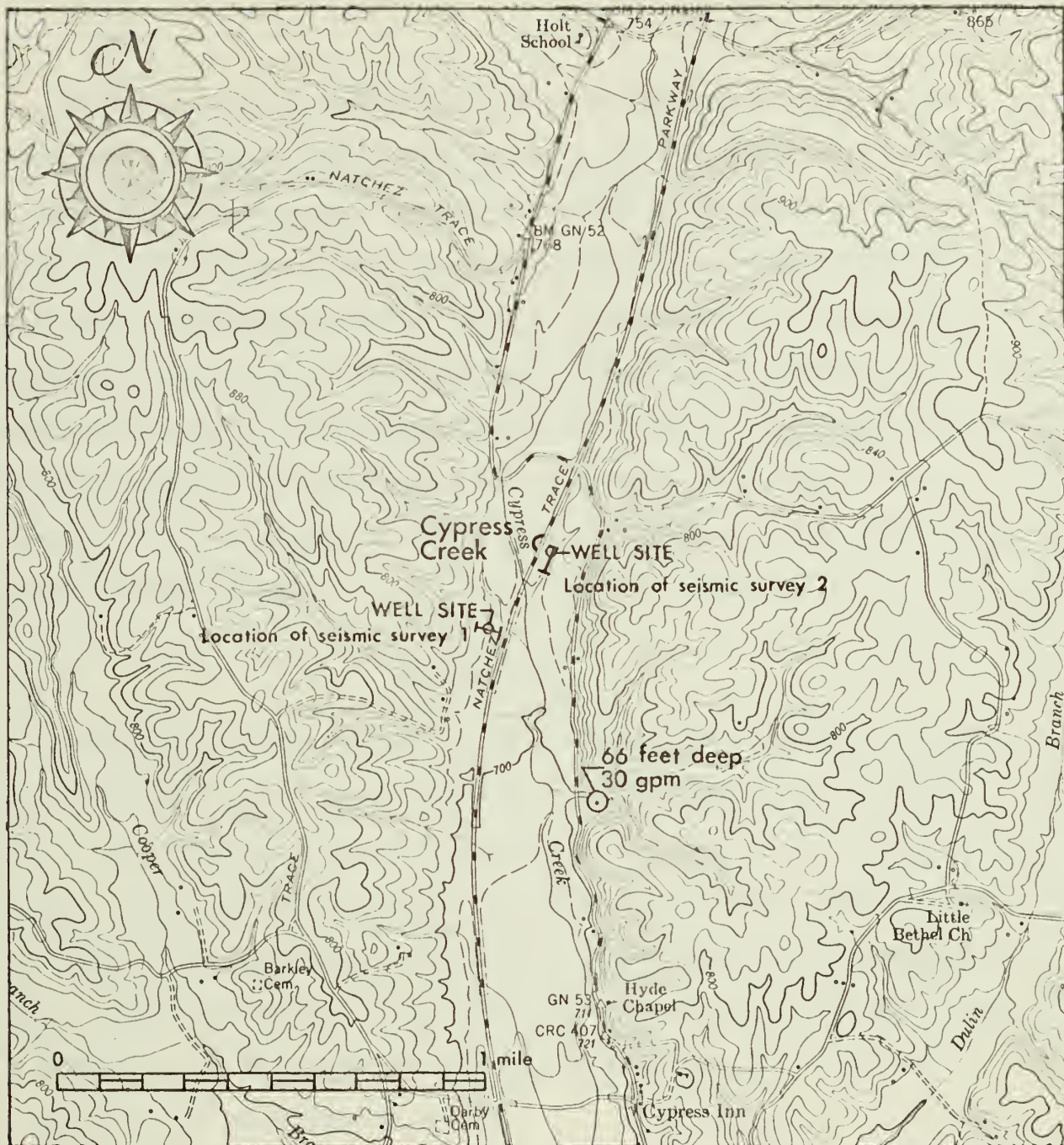


Fig. 6.--Location of Cypress Creek Picnic Area showing two seismic surveys made April 18, 1968, two alternate proposed well sites, and the depth and yield of a nearby well.

The overburden apparently is more than 90 feet thick in the Cypress Creek area. Seismic surveys were made April 18, 1968 along the lines shown on figure 6. In survey one, the velocity of the shock wave to a depth of 90 feet was an average of 5500 fps. This result is interpreted to mean that there is no bedrock within 90 feet of land surface. In survey two, the results were inconclusive, apparently because layers of dense chert within the overburden interfered with the shock waves. As further evidence for the interpretation of bedrock depth, a domestic well about 1/2 mile to the south of the picnic area (fig. 6) was drilled to a depth of 66 feet and did not hit bedrock.

Ground Water

Most of the gravel and sand in the overburden is mixed with clay and will yield little or no water. Ground water can be obtained from zones within the overburden which do not contain a clay matrix. The chances of finding water-bearing zones by test drilling are excellent. The domestic well (fig. 6) mentioned above yields 30 gpm from a water-bearing zone 51 to 66 feet below land surface. The yield from a test well at the picnic area is expected to be between 20 and 100 gpm, depending on the number and thickness of the water-bearing zones.

Ground water from overburden of the Fort Payne Formation usually is of very good chemical quality for domestic use; the water generally is moderately hard (60 to 120 mg/l) or hard (120-180 mg/l). About 30 percent of the wells yield water that contains more than 0.3 mg/l of iron. Otherwise the water may be used without treatment.

PROPOSALS

Leipers Fork Subdistrict Headquarters

A test well is suggested at the location shown on figure 3. The well should be drilled to a depth not to exceed 300 feet; the drilling is expected to penetrate a series of upper Ordovician formations, generally consisting of interbedded coarse-grained limestone and fine-grained, shaley limestone. The possibilities of obtaining the desired 5,000 gpd (gallons per day) are fair.

If the first test hole is unsuccessful in locating an adequate source of water, a decision must be made whether to try another shallow test hole, or to continue drilling to the Knox Dolomite. If an additional shallow (300 feet) hole is drilled, a location should be selected that is at least 100 feet in any direction from the first test hole; this distance should improve the prospects of obtaining a better well yield. A location 200 or 300 feet away would be even better in this respect. The top of the Knox Dolomite is about 1150 feet below land surface. There is a very good chance of obtaining 2 to 6 gpm from the upper 150 feet of the Knox. Additional water might be found at deeper depths.

Nashville Terminus

A test well is suggested at any location along one of the lineations (fig. 2). The well should be drilled to a depth not to exceed 300 feet; it can be expected to penetrate a series of upper Ordovician formations, generally consisting of interbedded coarse-grained limestone and fine-grained, shaley limestone. The likelihood of obtaining the desired 10,000 gpd from a single well is fair to poor. The yield of known shallow aquifer wells in the surrounding area ranges from less than 1 to 5 gpm; however, well yields greater than 5 gpm from the shallow aquifers are possible along one of the lineations.

If the test hole is unsuccessful, there are several alternatives:

(1) to continue drilling to the Knox Dolomite, (2) to drill another shallow test hole along one of the lineations or at the intersection of two lineations, or (3) to obtain water from the Harpeth Valley Utility District. The top of the Knox Dolomite is about 1200 feet below land surface on the valley floor at the Nashville Terminus. There is a very good chance of obtaining 4 to 10 gpm from the upper 150 feet of the Knox. Additional water might be found at deeper depths.

Nashville Terminus is within the area served by Harpeth Valley Utility District, Nashville. The Park Service may wish to tie into the existing water main along highway 100 if efforts to obtain a ground-water supply are unsuccessful.

Gordon House

A test well is suggested at either of the two sites shown on figure 4. The first test well site is suggested at any location along the lineation. The second test well site was chosen because of the correlation between topographic position and well yield. The number two site could be moved 200 feet in any direction, for convenience of the Park Service. The wells should be drilled to a depth not to exceed 300 feet; it is expected that they will penetrate approximately 20 feet of overburden, then a series of Ordovician formations, generally consisting of interbedded coarse-grained limestone and fine-grained, shaley limestone. The yields of known shallow aquifer wells in the surrounding area range from less than 1 to 11 gpm; larger well yields are possible along the lineation. Accordingly, it is suggested that the first hole be along one of the lineations. '

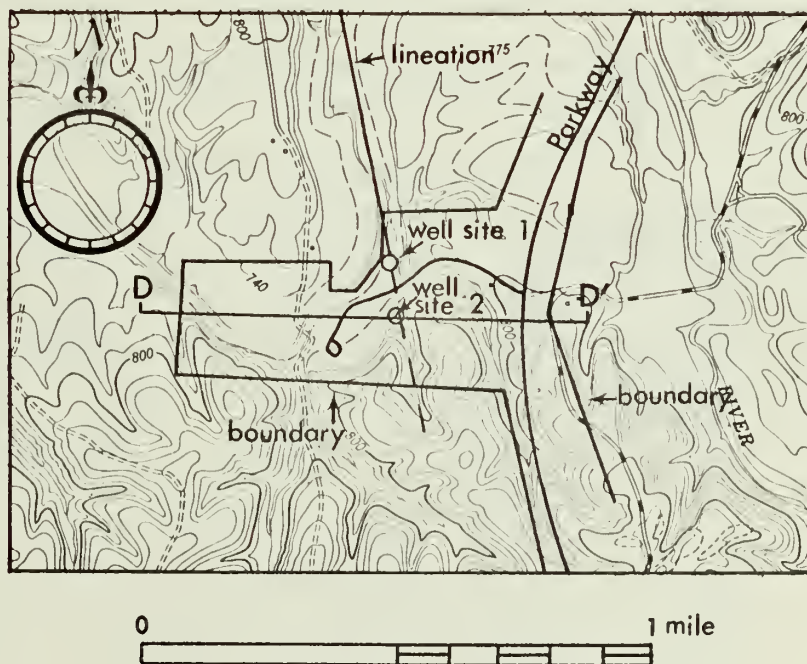
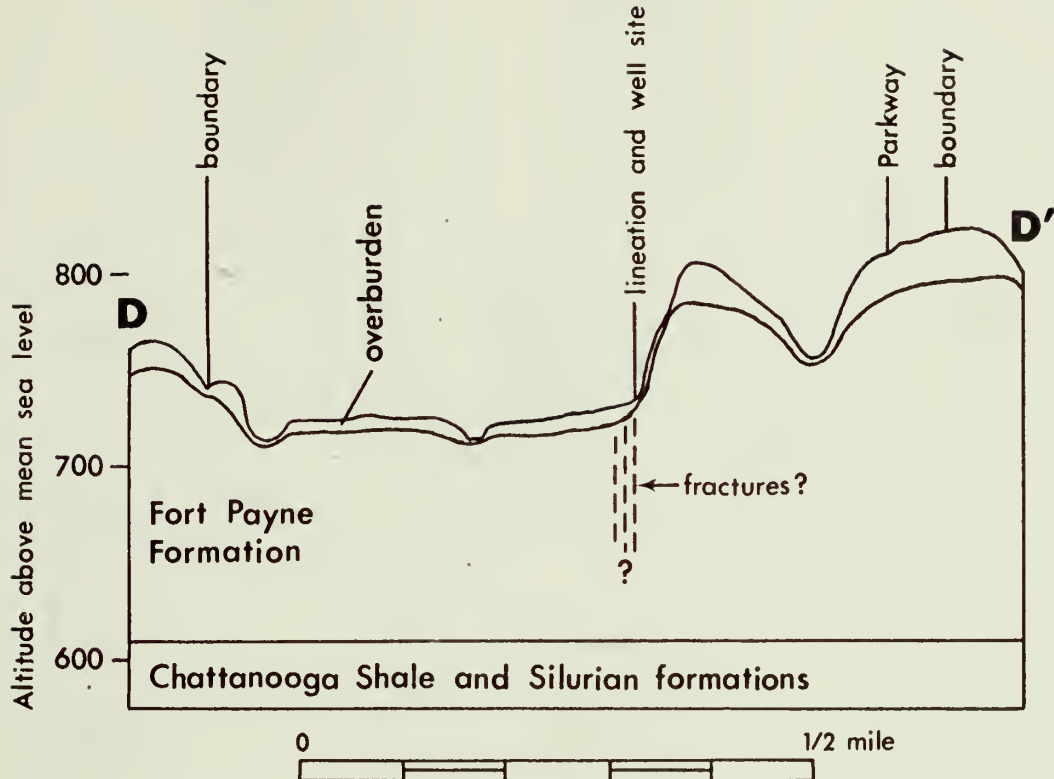
If these test holes are unsuccessful, a decision must be made whether to try another shallow (300 feet) test hole, or to continue drilling to the Knox Dolomite. If another shallow hole is drilled, a location should be selected that is 100 feet or more in any direction from the original test hole; this distance will improve the chances of obtaining better well yields. The top of the Knox Dolomite is about 1,050 feet below land surface in the Gordon House area. There is a good possibility of obtaining 5 to 10 gpm from the upper 150 feet of the Knox. Additional water might be obtained at deeper depths.

Metal Ford Historic Site

A test hole is suggested at either of the two sites shown on figure 5. The ground-water potential is good at both sites. The hole is expected to pass through about 10 feet of cherty-clay overburden and then through siliceous limestone of the Fort Payne Formation to the black Chattanooga Shale at a depth of about 120 feet. The chances of obtaining the desired 2500 gpd are very good. A test well would have about an 80 percent probability of yielding 5 gpm or more and a 60 percent probability of yielding 10 gpm or more.

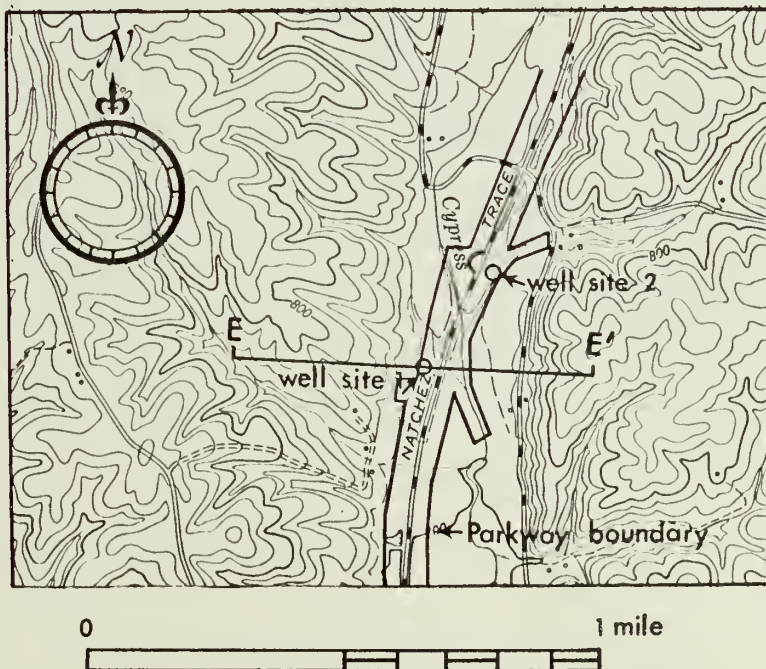
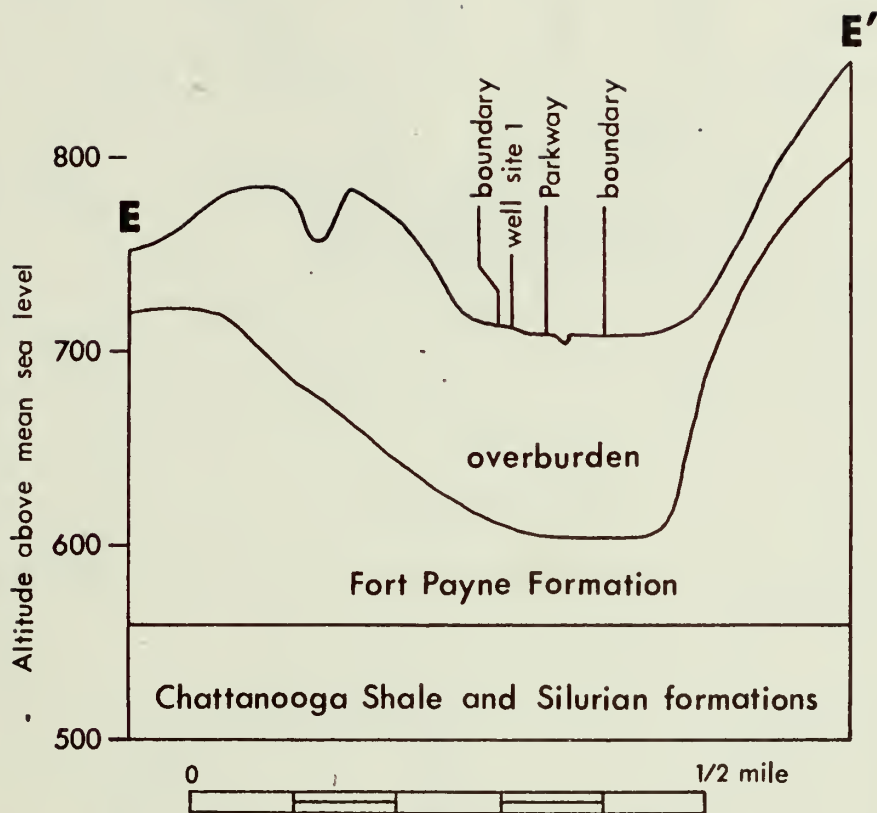
Cypress Creek Picnic Area

A test hole is suggested at either of the two locations shown on figure 6. Any well location should be satisfactory for obtaining water but most of the area around the picnic ground is subject to flooding. The maximum flood stage is unknown but the proposed sites are less subject to flooding and well contamination than most of the remaining area within the Park Service boundary. It is expected that the well will pass through at least 90 feet of gravel, sand, and clay. Park Service may wish to drill to the base of the Fort Payne Formation in order to test the maximum amount of water available, but an abundant supply of ground water should be available in the overburden. The probability of obtaining the desired 2,000 gpd is excellent. A well yield of 20 to 100 gpm is anticipated.



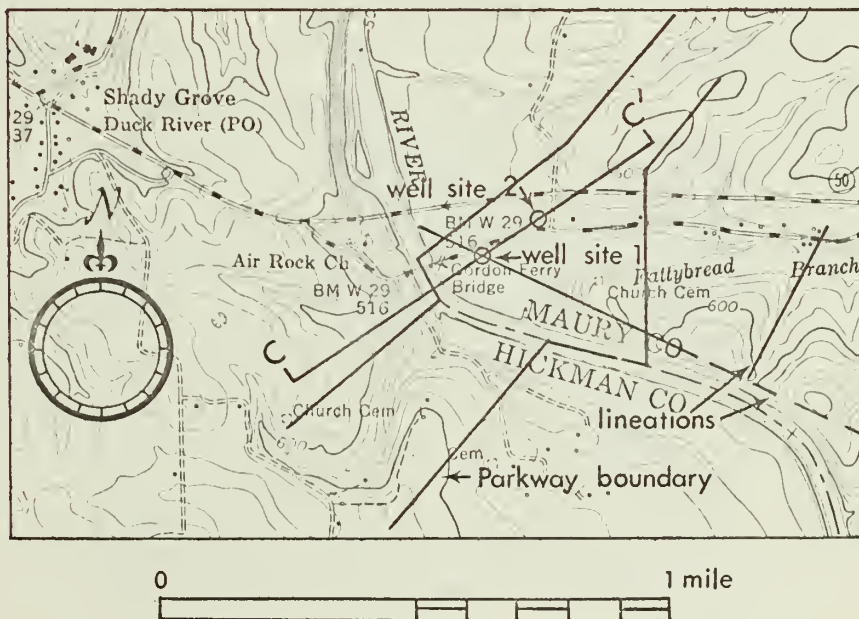
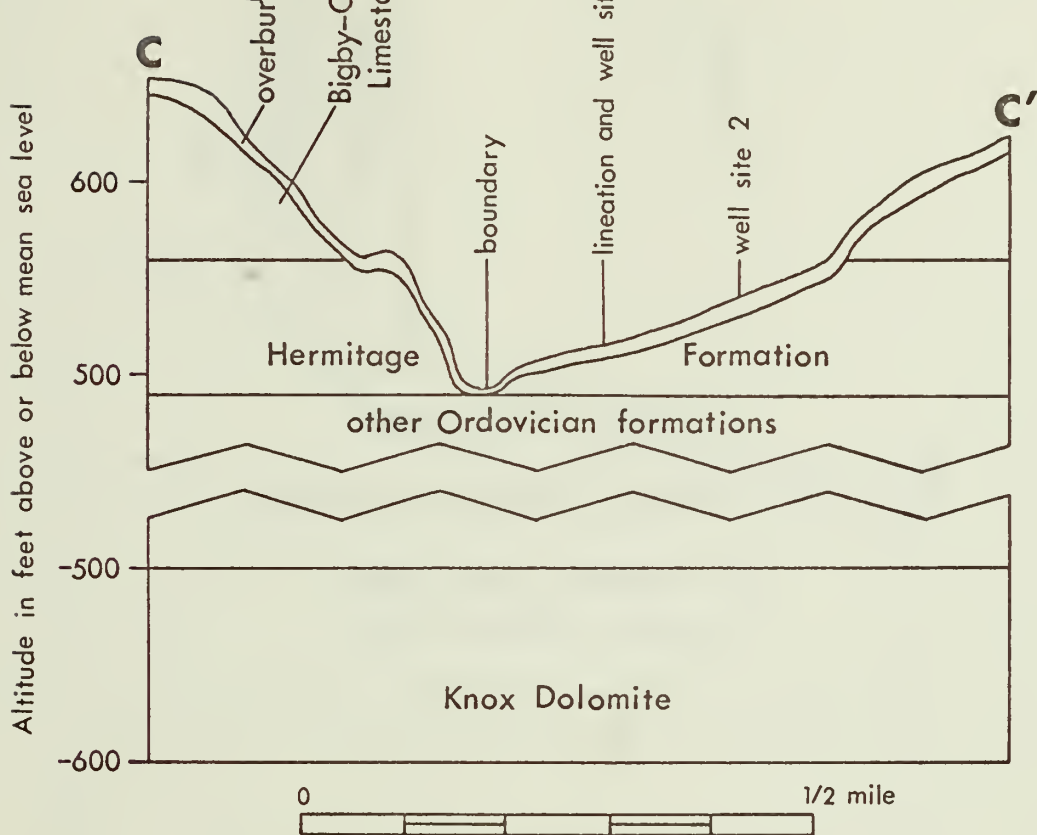
METAL

FORD



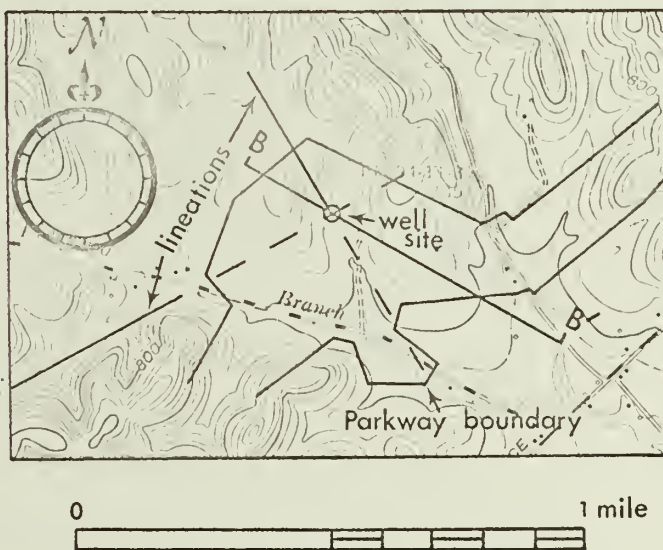
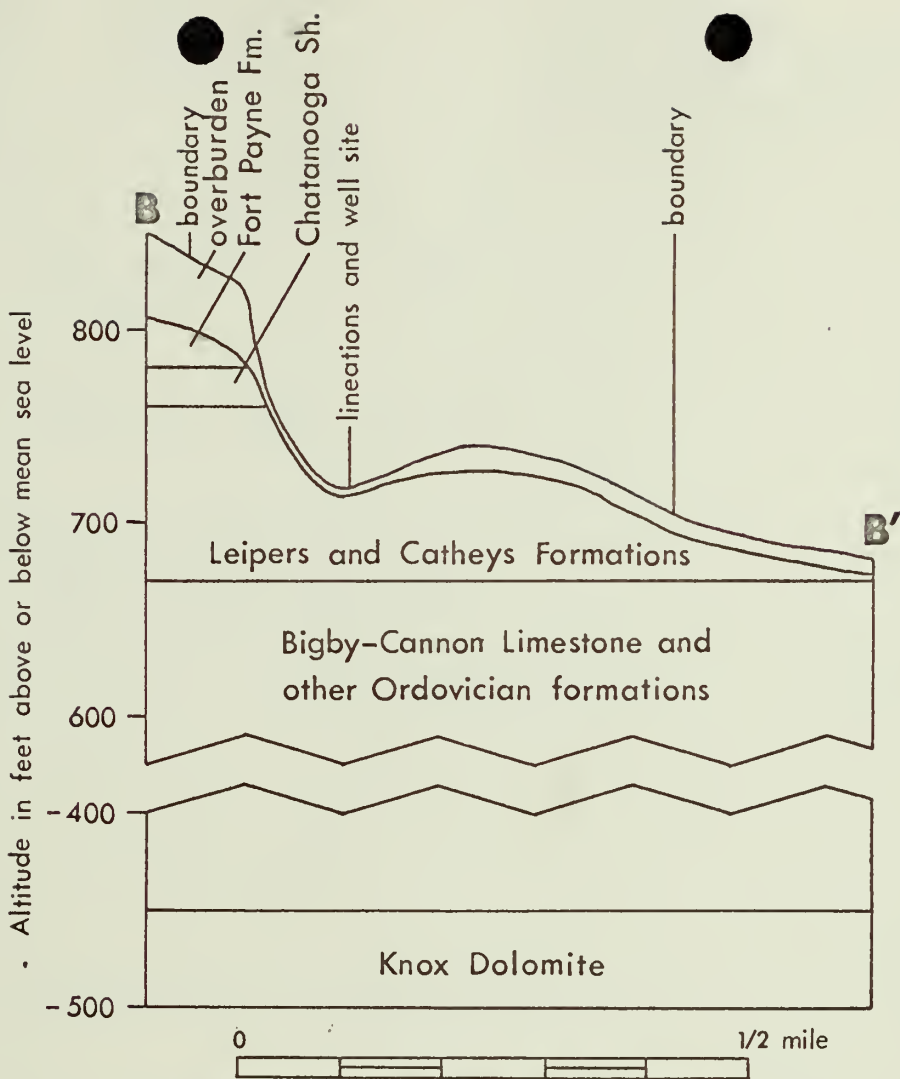
CYPRESS

CREEK



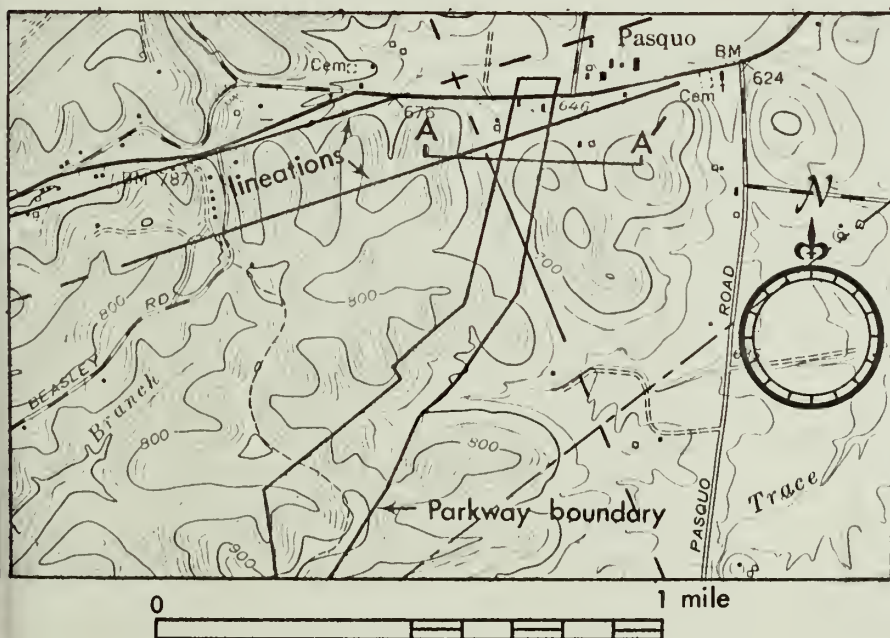
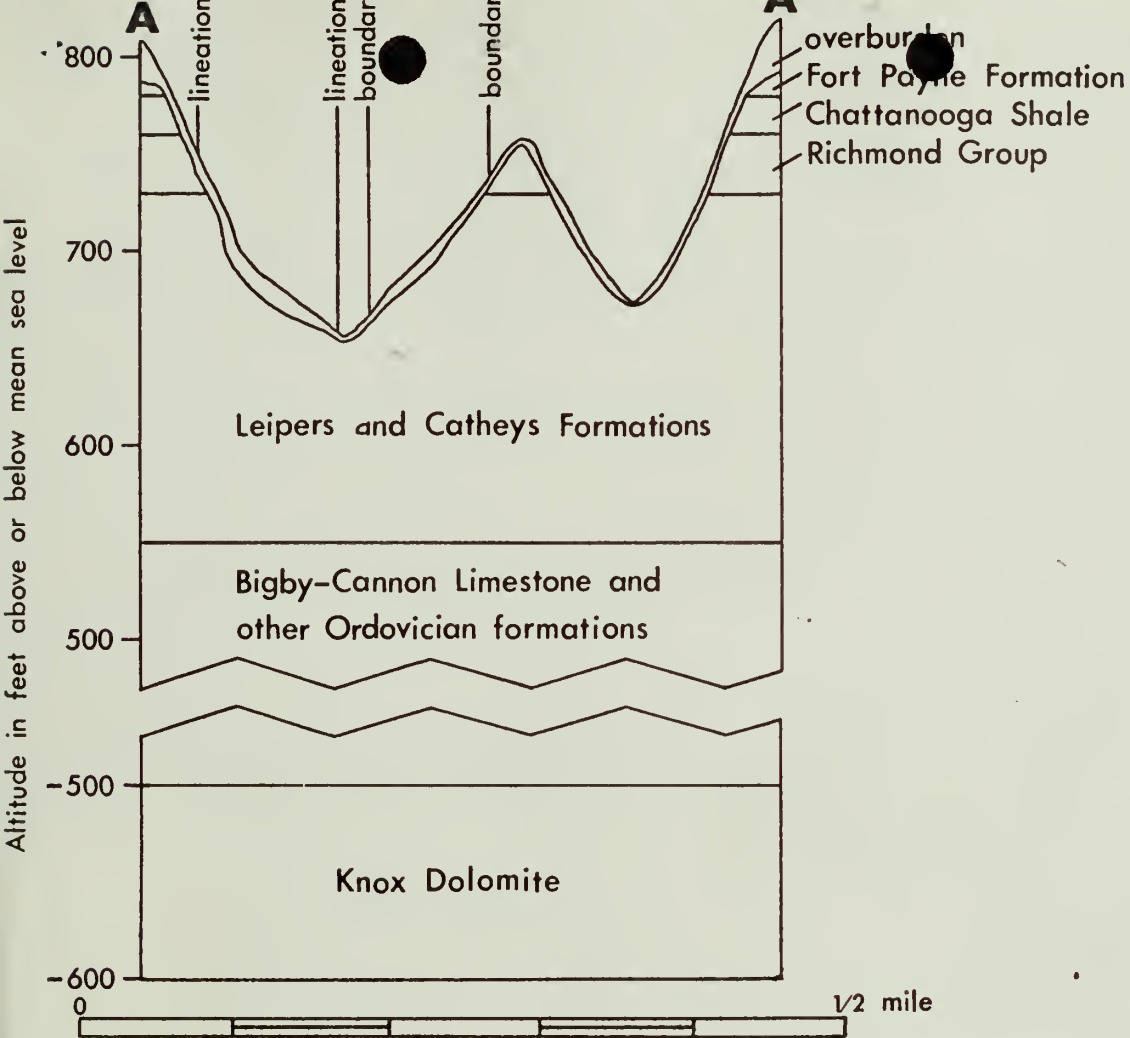
GORDON

HOUSE



LEIPERS

FORK



NASHVILLE

TERMINUS

